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Linguistic Analysis of Workplace Computer-Mediated Communication

by

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Abstract

Linguistic Analysis of Workplace Computer-Mediated Communication

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A variety of linguistic techniques were applied to a real world dataset to understand group dynamics in a small work group. Instant message conversations within a group of 22 individuals in a computational simulation group were collected for 15 months and analyzed linguistically. Communication patterns reveal functional uses of public chat, phases of group work, and individual differences in communication. This research contributed to an understanding of small work-group communication and how to use language to understand group dynamics in computer-mediated communication.

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INTRODUCTION

Communication is an integral aspect of effective group work (Jonassen & Kwon, 2001). This paper is motivated by a belief that the content of communication can show how groups complete collective tasks. The way in which group members communicate can reveal attitudes toward work environment and group, the effectiveness of the communication, and the interpersonal dynamics between group members.

Instant messages from a public chat room of a work group were gathered for linguistic analysis. The group developed simulations of natural disasters. Tasks were clearly delineated, with employees having specific roles from database programming to development of economic models. There was a high degree of interdependence and a collective group output. Much of the necessary communication centered on solving problems, including theoretical, technical and implementation problems. Over the 15 months in which instant messages were captured, future funding was initially likely, became threatened, and ultimately withdrawn. Once funding was uncertain, gradually group members either chose to leave or were reassigned to other positions.

Functional use of workplace communication

In this paper, tools are mobilized to detect the content of group communication. The content of group communication is valuable information in predicting group performance. It has shown to be relevant in at least two theoretical domains. The first domain is how socio-emotional statements affect group performance. Lebie, Rhoades, and McGrath (1996) proposed that there were two contrasting theories for the importance of socio-emotional statements. Bales and Strodtbeck (1951) describes socio-emotional statements, as opposed to task related statements, as those that show either solidarity,

agreement, and tension release or disagreement, tension, and antagonism. Socio-emotional statements may detract from task related effort or they may enhance interpersonal relationships (Lebie et al., 1996). Depending on which effect is more important, socio-emotional statements will have a different effect on group performance. Socio-emotional statements were inversely related to group performance among groups of strangers engaging in a single cooperative task in the lab (Jonassen & Kwon, 2001). In on-going group work, strong interpersonal relationships may be more important for maintaining performance.

Another theoretical domain in which the content of communication affects group performance is the type of information dispersed. It is an accepted research finding that group members are more likely to share common information on a decision making task than unique information (e.g. Stasser, Taylor, & Hanna, 1989). When uniquely held information is critical for making the best decision, this can detract from group performance. This tendency can be mitigated, for example when expertise is explicitly stated (Stasser, Stewart, & Wittenbaum, 1995). The patterns of information flow, can function as a gauge of group performance.

The first research question investigated in this paper is ***What are the functional uses of communication in the public chat?*** This question is addressed by examining the content words: nouns, adjectives, and verbs used in the daily instant message chat sessions. The techniques employed in this paper to detect the content of communication could be used with theories, like those discussed above, to track group performance.

Other studies have examined discussion topics in workplace computer-mediated communication (CMC). Issacs, Walendowski, Whittaker, Sciano, and Kamm (2002) have catalogued the functions of dyadic workplace CMC. They found a variety of uses for CMC, with the majority of communication task-related. A random subset of

conversations included: simple questions and information, work related discussions, scheduling and coordination, personal messages, greetings, and unanswered messages. The majority of conversations pertained to work; none of the other categories made up more than one third of the conversations. Of the work conversations, there were in-depth conversations necessary to complete work, discussions of work being conducted simultaneously in another window, and miscellaneous work-related issues. Despite the fact that conversation using instant messaging is heavily work related, there are distinct uses of instant messaging in the work place that are not task related.

This paper expands on this previous work by applying a different methodology to detect the content of communication. The automated tool that is used allows an analysis of a larger set of chat messages and does not presuppose the content areas. In addition, by examining public chat open to all group members, it is possible to capture group level coordination and problem solving not accessible in chat sessions between pairs.

Phases of group work

Not only does the content of discussion have relevance in gauging the health and performance of a group, the order in which topics are discussed matters as well. The order in which topics are discussed can show the process by which group members are working through problems. Two theories have been proposed that might explain why the order in which work is conducted might be important.

Bales and Strodtbeck (1951) propose a phase hypothesis in which task-related processes follow the order orientation, evaluation, and control phases. In Bales and Strodtbeck's model the orientation phase consists of an attempt to understand the problem, evaluation phase consists of evaluating possible solutions, and the control phase consists of coming to an agreement about the solution. Among groups with a task that

required these processes, they tended to follow the order theorized order. Bales and Strodtbeck hypothesized and found that socio-emotional statements tended to increase over time. Socio-emotional statements are being used near the end of the decision to re-cement interpersonal relationships that may have been disrupted during the decision making process.

The second theoretical approach relates to the importance of using meta-cognitive statements early in solving ill-defined problems (e.g. Jonassen & Kwon, 2001; Hirokawa, 1983). Unlike group work completed in the laboratory, real-world problems may require different skills. Problems encountered in the work place are more likely to be ill-defined problems (Jonassen & Kwon, 2001). Ill-defined problems are those problems in which the constraints on the problem may be unknown, the goal may be unclear, there may be multiple solutions or none at all. Compared to well-defined problems a successful approach to ill-defined problems includes a greater emphasis on meta-cognitive analysis of the problem (Shin, Jonassen, & McGee, 2003); that is, more effort toward planning than generating solutions. Effective work groups may devote more communication to planning and big-picture approaches to emergent problems.

The order in which meta-cognitive communication takes place may change the efficacy of the communication. By discussing possible solutions before consideration of the ways to approach the problem, it is possible to overly constrict the outcome space. Successful groups solving an open-ended design problem made more statements regarding the procedures the group would use to solve the problem at the beginning and end of discussion whereas unsuccessful groups made more of these procedural statements in the middle (Hirokawa, 1983). Successful groups analyze the problem before generating and evaluating solutions; the opposite is true for less successful groups.

Group work may be particularly helpful in eliciting meta-cognitive analysis. In a case study of middle school children solving math problems in small groups, most groups questioned faulty assumptions that were put forth by individual group members (Artzt & Armour-Thomas, 1992). The group that failed to find a solution did so because of faulty assumptions that were not questioned early on. This group had the fewest meta-cognitive statements. The process of group negotiation on how to go about solving the problem may elicit meta-cognitive analysis.

The second research question investigated in this paper is *At what times are group members engaging in different functional uses of the public chat?* To investigate the second research question, the degree to which communication topics were discussed was evaluated and tracked over the week and day. This technique combined with theories could be used to track group performance.

Language style and group performance

Language use has the potential to be a powerful tool in studying group dynamics. Language use has been shown to be helpful in detecting interpersonal relationships, including relative status, deception, and quality of close relationships (e.g. Sexton & Helmreich, 2000; Hancock, Curry, Goorha, & Woodworth, 2008; Simmons, Chambless, & Gordon, 2008). Mixed evidence has accrued on the linguistic properties of effective communication in promoting group cohesion and performance. The majority of studies on language use and group performance have tested these ideas in the laboratory with unacquainted participants in at most a few sessions.

Previous research has identified linguistic features that may be related to group cohesion and performance. Some of these elements are overall word count; pronoun use, specifically first person singular and plural; cognitive mechanisms; and emotion words.

Word count can predict better group performance. Overall word count is a measure of the amount of communication; increased communication may promote better performance. In flight simulations, groups of three unacquainted officers who used more words had higher team performance (Sexton & Helmreich, 2000).

Pronoun use shows how people are thinking about group members. Pronoun use may indicate whether individuals emphasize collective (e.g. 'we', 'our', 'us') or individual (e.g. 'me', 'my', 'I') actions and outcomes. It may reflect differences in the balance of status; higher status individuals tend to use more first person plural and less first person singular (Sexton & Helmreich, 2000; Kacewicz, Pennebaker, Davis, Jeon, & Graesser, 2009). There is mixed evidence for the relationship between pronoun use and performance. In the flight simulations increased use of first person plural led to better team performance (Sexton & Helmreich, 2000). In another study, groups of 4 males in assigned roles participated in 6 simulated search and rescue missions on the moon over 4 days. In this study, neither first person singular nor first person plural predicted team performance (Fischer, McDonnell, & Orasanu, 2007). Groups of 4-6 working on an interdependent encyclopedia task that in which group members used less first person singular and plural pronouns rated their group as being more cohesive (Gonzales, Hancock, & Pennebaker, 2009). For these groups pronoun use was unrelated to performance.

Cognitive mechanism words (e.g. cause, know, ought) are often used to make causal statements or reappraisals. These words can show increased cognitive complexity. In a work environment increased use of cognitive mechanisms may reflect increased task focus. Comparisons of cooperative groups in the lab with feedback from fellow group members and without feedback showed that groups with feedback maintained higher levels of cognitive mechanisms in the second half after feedback was given (Leshed,

Hancock, Cosley, McLeod, & Gay, 2007). The authors argue that these groups maintained high task focus, although providing feedback on communication did not alter group performance.

Emotional tone of communication can influence how messages are received and attitudes toward group work. Groups performing moon exploration that used more positive emotion words had better team performance (Fischer et al., 2007). Coded evaluation of communication found that successful groups used more assenting responses and less negative interpersonal behavior. Affect words were unrelated to group cohesion or performance for groups working on the interdependent encyclopedia task (Gonzales et al., 2009). These two experiments differed in the length of time needed to complete the task; the moon exploration task was much longer. Over a prolonged period the affective tone of communication may be more important for sustaining cooperative work.

These language features, which may be related to group cohesion and performance, will be useful for addressing our third and fourth research questions, discussed below.

Language style and group communication

Requests for information and good feedback are important components of effective group communication. By examining specific linguistic markers it is possible to estimate the extent to which feedback and information were given. Researchers have used question marks as a rough estimate of requests for information, since requests are usually phrased in terms of questions. Also, words giving assent (e.g. yeah, good, great) and negations (e.g. no, don't not) in a conversation give immediate feedback to a statement or question. Use of question marks has been shown to predict better group performance, when question marks were used early in flight simulations (Sexton & Helmreich, 2000).

In these simulations, lower status group members used question marks. Readers of threads in a forum were more likely to respond to a post if the post included question marks, suggesting that questions do elicit responses (Burke, Joyce, Kim, Anand, & Kraut, 2007).

Words giving assent and negations are often used as short responses to an idea or question. Negation use can reflect negative feedback given from one group member to another. For example, when in response to a new idea a group member expresses disapproval. Negations may also be a direct and clear response without any negative affect. When a group member responds to a question with a negative, he or she is being direct without being critical. Participants instructed to convey negative emotion used significantly more negations than participants instructed to convey positive emotion in a short instant message conversation between strangers (Hancock, Landrigan, & Silver, 2007). Negation use was correlated in a turn-by-turn inspection of unsuccessful hostage negotiations (Taylor & Thomas, 2008). On the other hand, participants assigned to groups of three that were allowed to have discussions on the side one-on-one with a group member used more negations but also shared more information which led to a higher probability of success on the task (Swaab, Phillips, Diermeier, & Medvec, 2008). The authors argued that negations in these discussions were used to objectively discuss and present arguments and share unique information. By engaging in arguments over information, a better decision was made.

Giving assent can be a form of positive feedback. Successful coalitions of business students participating in a negotiation task used more assent words than pairs or triads that did not form an alliance (Huffaker, Swaab, & Diermeier, 2008). In this experiment use of assent words may show agreement between individuals. However, frequent use of assent by an individual can show passivity and acquiescence. Leshed and

colleagues (2007) found that individuals in a small group engaged in a collective task that used more assent words were rated by group members as being less involved and not as task focused. These language features that related to quality of communication will be used to explore the last two research questions, discussed below.

Language synchrony

Speakers tend to adjust the style of language use to their partners in a conversation. The degree to which they, style match, depends on situational factors. It has been hypothesized that individuals with a stronger relationship, more liking, and more trust are will have a higher degree of language synchrony. Early work showed that student dyads communicating using instant messaging showed significant style matching in function words (Niederhoffer & Pennebaker, 2002).

Like non-verbal mimicry, language mimicry has been related to more cooperative outcomes. Language style matching in function words between members of group predicted rated group cohesion in a cooperative task in both face-to-face and computer-mediated-communication (Gonzales et al., 2007). In an investigation of language use between hostage takers and police negotiators, there was more language style matching for word categories in successful negotiations than in unsuccessful negotiations (Taylor & Thomas, 2008). Pairs of participants who cooperated more in an iterative economic game had greater similarity in word use for some stylistic elements (Scissors, Gill, Geraghty, & Gergle, 2008).

Research has yet to show whether there is language style matching between speakers who talk on an ongoing basis. Language style matching between a pair of speakers in instant message may indicate better a cooperative relationship and more

interpersonal trust. Based on this research it is expected to observe individual differences in how people language style match with each other.

Language style features, discussed above, which are related to group performance, communication quality, and interpersonal trust, will be used to address the third and fourth research questions. The third and fourth questions are: ***How does language use reveal changes in group dynamics over time?*** And ***How does the role of individuals in the group affect the language they use?***

Studying group communication is of immediate value to the management of collaborative work places. Yet, the majority of studies in the literature examining linguistic patterns in group communication have been done with groups studied in the laboratory. Work groups differ in important ways from laboratory groups, necessitating research into naturalistic group communication. Small work groups are often on-going for several months or years, which means, unlike in laboratory settings, individuals know each other well and will have to continue to work together after completing a project. Individuals have a strong interest in being perceived as good teammates; their livelihood may be dependent on these perceptions. Communication is on-going and may occur throughout the day and week, it is not limited to a small time window. This research has the ability to reveal work practices and give an example of how one could use automatic linguistic tools to study real workgroups.

DESCRIPTION OF CHAT ARCHIVE

Group Organization

The group was organized hierarchically with specialized roles based on expertise. There were four positions of management: line manager, group leader, deputy group leader, and group leads. The line manager was peripherally involved in day-to-day conversation in the chat room, but was responsible for securing funding for the group and negotiating with other administrators. The group leader had significant involvement in the group in the chat room, and would run group meetings. The deputy group leader was in charge of facilitating group work, including communication using the online chat system. The project leads also had management positions and were responsible for individuals working on a specific aspect of the group work.

Individuals were assigned to areas of work based on training and expertise. Individuals in the group had three main types of training; they had been trained to be economists, computer programmers, or analysts. Economists were responsible for designing the theoretical basis of the simulations and verifying that the simulations were sound from an economic perspective. Also, economists were assigned to non-simulation analytic projects completed independently from the main group work. There were three main economists, including the group leader. Computer scientists were responsible for implementing the theoretical economic principles into the computational simulations. There were two divisions of computer scientists: those that worked on running the simulations and those that worked on the software to display the results of the simulations. There were a total of six computer scientists. The analysts were in charge of evaluating and interpreting the results in order to check for mistakes in theory or

implementation. There were three main analysts and three student interns who helped with their work. Within each area of expertise, individuals had specific subtasks and experience, which meant that knowledge was well distributed.

There were other important distinctions between individuals in the group. Membership in the group ranged from 5 years to a few months. There were three classes of employees: full employees, contractors, and student interns. Two individuals were primarily members of another work group. Individuals had offices in geographically separate locations. The chat forum was introduced partially as a solution to the problem that not everyone was co-located. Nine out of the 18 group members had offices outside of the main location, these ranged from other locations at the main site, within the city, within the state, to out-of-state. Individuals would also work from home as they chose to, but particularly at night and on the weekends.

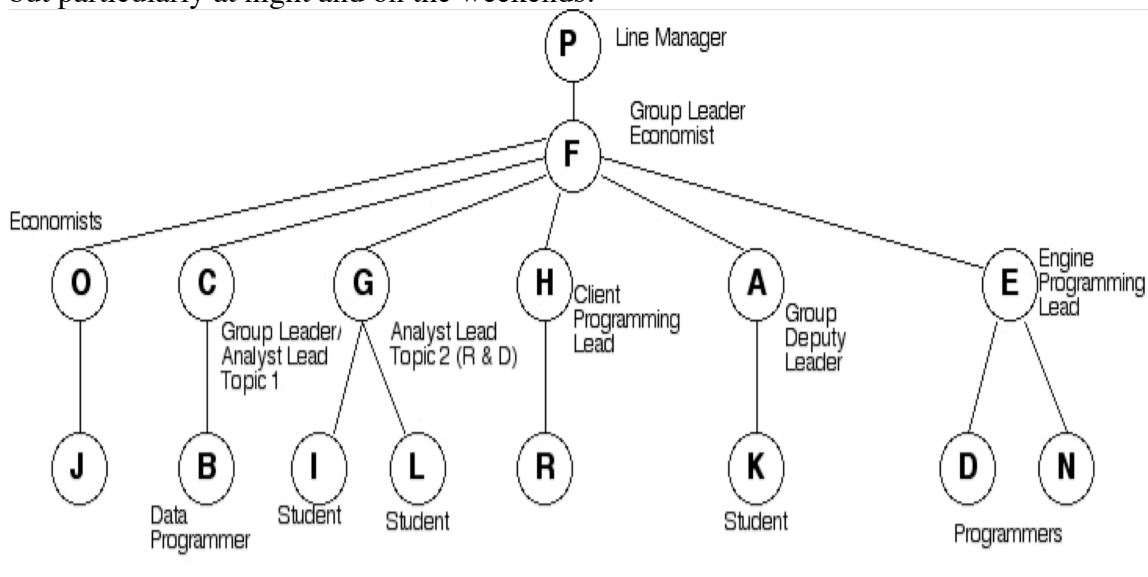


Illustration 1: Organizational chart.

Public Chat Forum

The chat forum was embedded within the proprietary software. The proprietary software was designed to display results of the simulations and serve as a medium of communication between users while they were trying to complete their work. Individuals were automatically logged in to the chat forum whenever they opened the simulation software to do work. Employees were also able to connect to the chat forum through other freely and commercially available instant message software programs. Users had the choice of sending a chat message to all individuals in the public chat forum or to any other group member individually. The public chat forum was typical of other instant message programs. Each user could see a list of other employees each with a name, self-selected picture, and status bar. The status bar had standard settings ‘Away’, ‘Active’, ‘Busy’, ‘Be Right Back’, ‘Do Not Disturb’. Ten to 20 messages remained present in the public chat at all times, visible to anyone as soon as they logged in. In addition, all messages for the public chat were recorded, and any group member could view these messages using an automatic system. Therefore, messages sent when individuals were not online could be accessed later. Because of the chat persistence and the fact that individuals logged into the system to complete work, individuals regularly used the public chat forum asynchronously to leave informative messages to the entire group. Conversations were conducted using the chat forum, so that they would be accessible to other individuals and serve as a public record to other group members.

Patterns of Use

Organization-wide rules required that individuals work from 10:00am to 3:00pm in their offices, to be available for group communication and meetings; however this requirement was not enforced. All employees and contractors worked full-time; the

requirements of projects often meant that individuals worked long hours, which would carry on into the evening and weekends. Of days in which messages were sent an average of 51.4 messages ($SD = 74.8$) were sent during peak business hours—9:00am to 4:00pm, Monday through Friday—and 39.7 messages ($SD = 63.5$) were sent at other times. As funding for the group diminished, individuals reduced their hours for this group and increased work for other groups. Throughout the time period conversations over the chat forum were episodic; some days no messages were sent. Messages were sent over the chat forum an average of 3.59 days per week ($SD = 1.46$).

ANALYSIS OF CHAT ARCHIVE

Method

Messages sent using a public chat program in a small work group were recorded for a period of 15 months, from September 20, 2006 to November 15, 2007.

PARTICIPANTS

The participants (N=22) were employees of a large research and development company working on large-scale computational simulations. Only 18 participants were included in the study because they had spoken at least 250 words. Of these 18 participants, 7 were female and 11 were male ranging from 22 to 64 years old. Sixteen of the 18 responded to our request to complete follow up surveys. At the time the messages were sent to the public chat forum all participants were aware that their comments were being recorded.

PROCEDURE

Participants were recruited to complete follow-up questionnaires in October 2008 after the period in which the comments were recorded. Participants completed several psychological questionnaires about themselves including background information, measures of personality, social skills, and self-esteem. Participants rated their attitudes toward the public chat forum, the group functioning and the other group members. With respect to their experience in the group participants were asked two questions of interest in this study 'To what degree did you experience interpersonal conflict?' and 'To what degree did you feel pressure from other group members?' With respect to this study, participants rated each group member on two questions: 'Has higher social status' and 'How well do you know this person?'

LINGUISTIC ANALYSIS

Recorded instant messages were grouped into divisions by the person who sent it; by the chat session; and by the time periods the month, the day of the week, the hour of the day. Using the same methodology as Isaacs and colleagues (2002), chat sessions were defined as consecutive messages without more than a 5-minute delay between responses. There were a total of 1013 chat sessions, 48.9% of these chat sessions were statements made by a single speakers. Isaacs and colleagues also found a significant portion of sessions with a single speaker (23.4%). In this sample, there may be a higher percent of these sessions because individuals would leave publicly available messages by using the chat forum. In terms of analysis of content, chat sessions with one speaker were a small contribution they made up only 8.3% of words used. The other 51.1% of chat sessions had two or more speakers and represent more typical conversations. Language was analyzed in these different divisions.

The language was analyzed using three different techniques. The language was processed using the Linguistic Inquiry and Word Count (LIWC) program (Pennebaker, Booth, & Francis, 2007). This program calculates the frequency of words in different psychologically meaningful categories.

For 276 chat sessions in which only two individuals sent messages Language Style Matching (LSM) was calculated between these two individuals. LSM measures the degree to which two individuals use similar writing style. It is calculated by averaging the absolute difference scores for nine function word categories measured by LIWC (Gonzales et al., 2009). The nine function word categories are: personal pronouns (e.g. I, you, they), indefinite pronouns (e.g. this, it, that), articles (e.g. a, an, the), auxiliary verbs (e.g. am, have, being), common adverbs, (e.g. very, especially, nearly) prepositions (e.g. on, above, along), conjunctions (e.g. and, but, because), negations (e.g. no, not, never),

and quantifiers (e.g. bunch, few, lots). The absolute difference score for any category is calculated on texts, A and B, using the following formula:

$$LSM = \frac{|categoryscore_A - categoryscore_B|}{(categoryscore_A + categoryscore_B)}$$

If the no function words are found in that category for both individuals the score is omitted. LSM was calculated between two individuals in the same chat session and calculated LSM from two individuals in different chat sessions. To calculate LSM between individuals in different chat sessions, statements by speakers in the dyadic conversations were randomly shuffled to pair speakers from different conversations. LSM was calculated using the texts of these randomly assigned pairs. A LSM score was generated as an individual level variable by averaging LSM scores calculated for each dyadic chat session in which he or she spoke.

Following the meaning extraction method proposed by Chung and Pennebaker (2008) a list of the most frequent non-function words in chat sessions with at least 100 words were generated using WordSmith. Of these selected chat sessions 90.9% of these had at least 2 speakers; these sessions were more traditional conversations. All words that were in at least 10% of the selected sessions were included. The final list consisted of 105 word stems. For each of these word stems whether each session included at least one lexeme was recorded. This generated a binary variable, presence of item in the chat session.

Principle component analysis was applied to the data treating each word stem as an item, each chat session as an observation, and presence of an item in the chat session as the dependent variable. The scree plot revealed either two or three factors were appropriate; all had an eigenvalue greater than 1. The factors were rotated using varimax rotation and only items with loadings greater than 0.30 were retained. Conceptually the

words stems fit into three categories. Twenty-one word stems did not load with a high enough loading on any of the three factors. These three factors were treated as three separate topics. To measure the degree to which participants sent messages about each topic, for each text division the percentage of words that were a lexeme of a word that had loaded onto the factor were recorded.

Results

TYPES OF COMMUNICATION

The content of the chat sessions demonstrates how group members used the public chat to complete work. The meaning extraction method was used to automatically and atheoretically group frequently used content words that were consistently used during the same chat sessions. Based on this approach three main topics of conversation were identified. The first topic, named social organization, included word stems that act as niceties (e.g. lol, hehe), affirmations (e.g. good, yeah, great, cool), coordination of people (e.g. call, meeting, chat, send), and broad communication of ideas (e.g. http, show, read, thinking, interesting, question). Social organization is important in communicating, coordinating and maintaining a positive work environment.

The second topic, called in-depth work problem solving, was directly related to the economic (e.g. production, market, supply) and analytic (e.g. results, answer, problem, report) aspects of the work. Chat sessions, which scored high on this topic usually involved participants who would work on a specific work related task. These sessions were characterized by using more words per message ($r(294) = 0.17, p < 0.01$). It may be the case that because they address more complicated ideas, in-depth work conversations can only be communicated through longer messages. These were specific problem solving discussions.

The third topic, which named technology problem solving, included software (e.g. machine, file, client) and programming words (e.g. code, version, data). These chat sessions about tools involved solving a technical problem with the technology, testing software, or discussing the relative value of different tools. For this group, trying to solve a technical problem is different from trying to solve a theoretical problem. In solving a technical problem many people suggest solutions, work on separate fixes, and/or help test to see what the problem might be.

Table 1: Word stems for identified types of communication. XXXX marks the name of the group's proprietary software.

Social Organization	Yeah, lol, hehe, question, good, stuff, hear, people, guys, talk, idea, sounds, kind, nice, true, interesting, point, set, guess, pretty, great, work, time, show, bad, big, hard, thing, call, lot, read, thinking, cool, add, send, meeting, sense, chat, remember, real, http
In-depth Problem Solving	Firms, demand, production, BEA, market, supply, define, simulation, number, buy, based, case, means, results, view, answer, analysis, cost, reason, change, day, state, hmm, find, problem, fixed, report
Technology Problem Solving	XXXX, streamer, file, runs, client, running, code, test, fine, machine, version, email, small, long, data, current

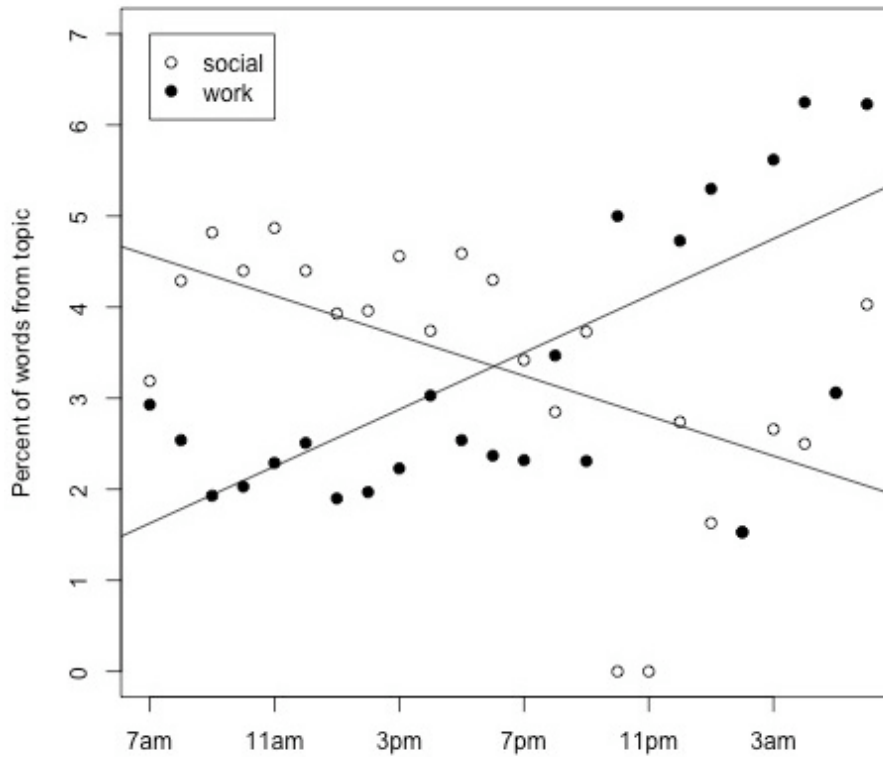
An analysis of conversation topics reveals the presence of social organization as well as task specific conversation in informal group communication.

PHASES OF GROUP WORK

The content of conversation changed over the course of the day and the week. The pattern of conversation topics suggests phases of group work. Over the course of both the work day and the work week, discussion focused on social organization early and in-depth work problem-solving later. Linear regression models were used to test whether

procession of hours in the work day, that is the period of a work day beginning at 7am and proceeding to the beginning of the next day (6am) could predict changes in language use. Percent of words from the social organization category were negatively related to hours in the work day ($F(1, 22) = 10.35, p < 0.01, \beta = -0.11$); percent of words from the in-depth work discussions category were positively related to hours in the work day ($F(1, 22) = 14.28, p = 0.001, \beta = 0.16$).

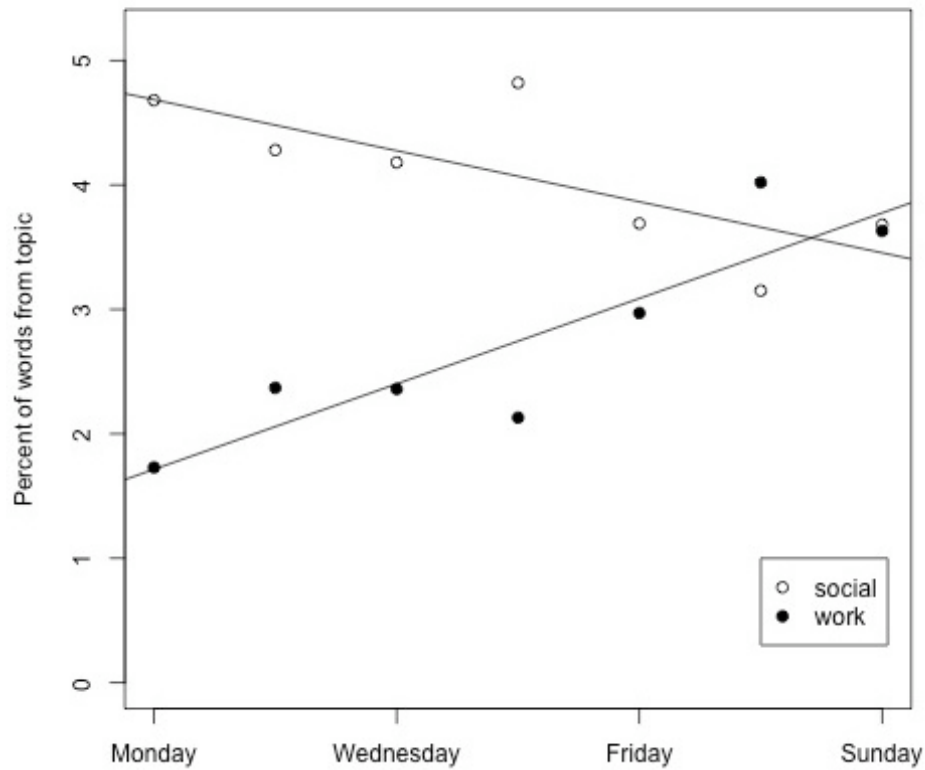
Figure 1: Conversation topics across the hours beginning at the start of the work-day 7 a.m. and proceeding to the beginning of the following day, 6 a.m.



Linear regression models in which day of the week from the start of work Monday to the end of the week Sunday to predict word use, showed that work day marginally negatively predicted use of social organization words ($F(1, 5) = 6.20, p = 0.055, \beta = -0.21$). Day of the week positively predicted use of in-depth work problem

solving ($F(1, 5) = 19.21, p < 0.01, \beta = 0.034$). There was no relationship between use of words pertaining to technology problem solving and time period. Topic scores were calculated as the percent of topic words out of the total number of words. Even though the percent of words for each topic is low, less than 7%, since topic scores were calculated as percent topic words out of the total number words there may be a significant inverse relationship between these two topics because there is a trade-off between the use of different content words. Fifty percent of words in naturally produced language are function words (Chung & Pennebaker, 2007), suggesting that content words can only make up to fifty percent of words. Many of these content words, will be infrequently used words that were not captured by our technique; topic analysis was limited to words that appeared in at least 10% of texts. As might be expected social organization and in-depth work problem solving were inversely related. However it was unexpected that they should change over the day and day of the week.

Figure 2: Conversation topics by the day of week, beginning Monday and proceeding until the end of the work week Sunday.



GROUP DYNAMICS OVER TIME

Language use shifted over the 15 months in which conversation was recorded; shifts in language suggest that the reorganization of the group during this period is reflected in language use. All messages over public chat were collected during a period when the group was dissolving. As funding for the group waned, group members left or were reassigned to other teams. The number of speakers participating in the public chat channel decreased over the months ($F(1, 13) = 11.65, p < 0.05, \beta = -0.59$). Language use also changed during this period. There was a marginal reduction in amount of communication measured by word count over the months ($F(1, 13) = 2.95, p = 0.11$). Trends in linguistic categories over time suggest a reduction in the complexity of

discussions. The use of cognitive mechanisms (e.g. cause, know, ought) decreased over time. Cognitive mechanisms are associated with cognitive complexity and reappraisal. These words were important in problem solving about work.

Linguistic categories that have been associated with group performance and communication quality were also examined. There was a decrease in first person plural pronouns over the months and no significant difference in first person singular. Fewer first person plural pronouns suggest changes in status relationships or fewer references to the group. In fact, Person A, who participated the most in the public chat and was deputy leader for the group, had a significant decrease in first person plural use over the time period ($F(1, 13) = 16.53, p < 0.01, \beta = -0.14$).

Table 2: Changes in language use in public chat with respect to month over the 15 month period comments were recorded.

		Month β	<i>SE</i>
Participation personal pronouns	word count	-1090	637
	first person plural	-0.0921**	0.0245
	first person singular	0.0480	0.0362
complexity	cognitive mechanisms	-0.156**	0.0442
emotion	positive emotion	0.0744*	0.0338
	negative emotion	0.0385**	0.0116
communicati on	assent words	0.00264	0.0317
	Negations	0.0578**	0.0181
	question marks	-0.00268	0.0274

* $p < 0.05$, ** $p < 0.01$

Over the same period there was an increase in negative emotion words and positive emotion words. Intensity of emotion may have increased as there was increased

uncertainty about the future of the group. Quality of communication in a synchronous medium is partially determined by the feedback given and the requests made. Assent words, negations, and question marks were examined to measure interchange. There were no significant differences in the use of assent words or question marks over the months. There was an increase in the use of negations. These patterns in language suggest that the language used in public chat may reflect changes in group atmosphere and future prospects.

WORK RELATIONSHIPS

Speakers change language to accommodate their partners. Increased linguistic mimicry has been associated with increased feeling of rapport and liking. In a group, language style matching was found to be associated with group cohesion. In this work group pairs of individuals in a conversation have significantly greater language style matching than randomly paired individuals ($t(556) = 2.84, p < 0.01$). Mean language style matching in a conversation was higher than ($M = 0.43, SD = 0.28$) mean language style matching between randomly paired text samples ($M = 0.36, SD = 0.26$). Language mimicry in style may be important in building and maintaining relationships in a work place. Some individuals had lower than average language synchrony with their conversation partners. Group members rated as having higher social status had significantly lower LSM ($r(15) = 0.62, p < 0.01$).

A more in-depth examination of group ratings and round robin ratings of group members shows differences in language based on ratings. As has been found in past work, rated social status was negatively related to use of first person plural ($r(16) = 0.51, p < 0.05$). Perceptions of pressure from other group members was positively related to use of assent words in the public chat ($r(14) = 0.50, p < 0.05$). Use of question marks was positively associated with perception of interpersonal conflict in the group ($r(14) = 0.66,$

$p < 0.01$) and negatively associated with rated familiarity of individual by other group members ($r(16) = -0.61, p < 0.01$).

Discussion

The language expressed in the public chat forum was used to dissect group communication and group dynamics. The meaning of words used helped identify the topics of communication and the patterns in which topics were discussed. The frequency of style words reflected changes in group dynamics over time, and individual differences in group roles.

FUNCTIONAL USE OF COMMUNICATION

Communication is a necessary part of group work. Identifying the topics of communication can suggest what discussion takes place to complete work. Another study examining dyadic instant messages in the work place found that the majority of conversations were work related (Isaacs et al., 2002). A description of the functional uses of public chat can suggest the degree to which different types of communication are necessary.

The meaning extraction method was used to identify three independent topics of conversations in the instant messages: social organization, in-depth work problem solving, and technology related problem solving. These results support Isaacs and colleagues (2002) finding that the majority of conversations using public chat in the work place are work related.

These topics of conversation were derived using an atheoretical language method, yet conceptually these topics do a good job of explaining instant message chat sessions in this group. In chat sessions which scored high on social organization participants planned future times they would discuss work in detail. Past research has found that instant

messaging is useful in setting up communication in other mediums (Isaacs et al., 2002; Scholl, McCarthy, & Harr, 2006). The fact that instant messaging is informal and can be used asynchronously as well as synchronously enables individuals to arrange future communication without interrupting current work. This function represents necessary group coordination. In this excerpt, individuals share information about the cancellation of a group meeting that was going to be held in person:

PERSON C: FYI the department **meeting** was canceled . . . Person P had a last minute need to cancel . . .

PERSON B: ahhhhhhhhh – it’s been cancelled 200 times!!!!

PERSON B: I just **called** her about it and she known’s . . .

PERSON C: I know . . . I **called** her too.

PERSON B: LOL

In these conversations, group members share information and opinions that are useful in providing background for their work. In this conversation, individuals discuss relevant articles. By sharing resources information is disseminated between group members and everyone is better informed.

PERSON B: Hey – did you **read** that paper yet? I am still on page 3 but it is **real good** so far.

PERSON D: **yeah** I had **read** it before

PERSON B: ah – that was a sweet find by Person G

PERSON D: yes I agree

The tone of chat sessions that scored high on social organization was positive. These sessions are laced with social niceties and affirmations like ‘lol’, ‘cool’, ‘great’ which ensure messages are interpreted positively. Conversations that scored high on being about social organization are not limited to conversations in which individuals simply socialize or discuss personal events. These conversations are an important functional use of the public chat which are useful in completing work.

The second topic, in-depth work problem solving, involved detailed task related discussions. Often multiple conversations between the same individuals on the same topic

took place over several days. These were specific problem solving discussions, in which individuals combined knowledge to solve the task at hand. The content words that were related to in-depth work problem solving involved economic and analytical words. Two of the three areas of expertise in this group, economics and analysis, are captured by this topic. These were the two aspects of the division of labor that required discussion of theoretical reasoning. In this conversation Person A and Person C had been having several conversations about the same topic. Person C leaves a series of messages about the problem, while Person A is away.

PERSON C: I have spent the last little while checking out unmet **demand** and consumer surplus on the 365 day run (no disruption). I am using seafood as an example here. Given that the **supply-demand** ratio is ~ 2.5 (lots of excess **supply**) we shouldn't have any unmet **demand** theoretically. However the unmet **demand** nationally for seafood is 2.2 million. There are two-three **DEFINE** file issues that could cause this. . . .

The problem that Person C and Person A, two analysts, are describing is a problem with the underlying model guiding the simulations that is causing inconsistent results.

The third topic, technology related problem solving involved discussing immediate software or hardware problems or discussion of the trade-off between work related tools. These chat sessions were different than sessions in which individuals problem solved about the theoretical work concepts. In solving a technical problem many people suggest solutions work on finding a fix or helped to test what the problem might be. The third area of expertise is captured by this topic. Completing group work required development of computational resources to acquire data, run simulations and to display the results. Working on technological problems that arose, required technical skill. In this chat session a problem with the simulation software arises:

PERSON C: For those working on Katrina; I have submitted a new **run**. The **DEFINE file** is still being verified so please be patient.

PERSON C: rats a **run**-time error!

PERSON C: anyone know what this error is...?

PERSON F: which?

PERSON C: Hold on ...

PERSON F: did we lose the **streamer**?

PERSON C: looks like it..

PERSON C: FirmBuyer.cpp:679: failed assertion 'total != 0.0'

PERSON F: I'll look it up.

PERSON C: thanks!

Through public chat there is a fluid exchange of information about useful tools and there can be a bottom-up coordination when problems in joint tools arise. Expertise from multiple individuals is being employed at the same time. Also, everyone is well informed when a problem arises because it is announced to everyone who is working at the time and available to individuals when they log in later.

The division between theoretical conversations, which involved economic and analytical terms, and technology problem solving conversations, which involved words referring to technical tools mirrors distinct areas of expertise within the group. This finding supports the conceptual coherence of this methodology and its applicability to automatically extract and track themes from communication data. This methodology which was automatic and atheoretical accurately separated socio-emotional and task oriented topics, it further separated task-oriented topics into two distinct areas of expertise.

In this dataset there were three main topics of discussion. While the content of these discussions is specific to this work group, these functional uses of communication may be present in other work groups. In other groups task focused discussions will not be use words such as 'demand', 'production', 'market' yet task related discussion is an important part of group communication. Similarly, discussion that is focused on social

organization, that is coordination, planning and big picture thinking, may also be vitally important to completing work. In laboratory settings socially motivated communication is often negatively related to group performance in cooperative tasks, because there is a trade-off between effort put into the social aspects of working together and working on the task at hand (Jonassen & Kwon, 2001). In contrast, by studying a small group in the work place, which 1) works over an extended period of time and 2) works on real-world often ill-defined problems, we observe that effort put into social organization promotes team performance. Further studies should examine the relationship between task related and social related communication and group performance in non-laboratory work groups.

PHASES OF GROUP WORK

Past research in group problem solving suggests the importance of two distinct types of group communication: planning and task related discussions (Jonassen & Kwon, 2001; Artz & Armour-Thomas, 1992; Hirokawa, 1983). Not only does this literature suggest that planning how to solve a problem may be as important as discussing possible solutions it also suggests that the order matters (Hirokawa, 1983). I identified three independent discussion topics. Topics included a topic that focused on planning future communication, giving feedback on ideas, discussing ideas broadly, and another topic that focused on trying to solve theoretical problems that arose in completing work.

These two types of communication occurred more frequently in different parts of the work day and work week. Social organization decreased over the work day and work week, the opposite was found for in-depth work problem solving. The trade-off between social organization and in-depth work problem solving over the day and week suggests that these topics represent two steps in an iterative process of completing work. The work day and work week are natural cycles in office work.

There are a few possible explanations for why this pattern may have been observed. The topic named, social organization, functions as an organizational and socio-emotional communication. As the week and day progress there is less time left to arrange future discussion. Effective coordination may occur when the most people are online and available, because of when people work there would be most people present in the morning and during the weekday. More conversations may center around social organization when people are most available. Along the same lines of reasoning, conversation may only take place on non-peak work hours when there is a pressing work problem to solve, which is why these conversations may be more task focused.

Finally, these results may be partially supported by the literature on meta-cognitive statements and problem solving in groups. Among conversations that score high in social organization are conversations in which work is discussed more broadly and group members plan out how they are going to approach a problem. Thinking about a problem broadly may be important in avoiding poor assumptions, particularly in solving real world problems that may not be well defined or solvable (Jonassen & Kwon, 2001). Coordinating about future discussions, how to go about solving a problem, or effort put into a problem may be an important initial step in being able to carry out more work later.

In this dataset it was shown that social organization and in-depth work problem solving are two main topics of discussion. The frequency of these topics over the work day and week suggested phases in functional use of communication. One possible extension is that discussions that focus on coordination, planning and big picture thinking promote and support subsequent task related conversations. Further research should look at whether groups that engage in discussions that focus on social organization first and then task related discussions are better able to complete work.

LANGUAGE USE REFLECTS CHANGING GROUP STATUS

Language style may be helpful in tracking group dynamics over time. Preliminary empirical studies that examine group performance and coherence suggest that certain language features can predict group outcomes (Sexton & Helmreich, 2000; Fischer et al., 2007; Gonzales et al., 2009; Leshed et al., 2007). The way in which individuals refer to fellow group members, the complexity of statements, the emotional tone of statements, and communication style can help demonstrate changes in group dynamics. Instant messages were collected over an extended period of time; membership of the group and certainty of the group's future changed over this period. By examining which language features changed and how they changed, we can determine which of them may be important markers of group dynamics.

First person plural has been related to high group performance (Sexton & Helmreich, 2000). Use of first person plural may demonstrate positive relationships between individuals in the group. For example discussing referring to a past conversation Person A says 'Person D and I were brainstorming ideas for (yet another) collaboration assistant. **We** were thinking about a helper who returns from queries.' In this example first person plural refers to Person A and Person D and demonstrates positive collaboration between group members. There were no changes in the use of first person singular.

Changes in cognitive mechanisms, emotion words, and communication discourse markers suggest a reduction in the complexity and an increase in the emotionality of conversation. There was a decrease in the use of cognitive mechanisms. Cognitive mechanisms are used when individuals are processing and discussing information. There was both an increase in positive and negative emotion words. Conversations may have become more emotional as there was more uncertainty about the prospects of the group.

Individuals were unhappy to be forced to leave the group, yet may not have directed that towards other group members. There was an increase in the use of negations over the time period. In this group increase in negations may be explained best as an increase in technical problems. For example in this exchange Person B and Person A try to work out a problem:

PERSON B: hm. Uh. I **never** saw it. Sorry.

PERSON A: Let me try it again that way . . .

PERSON A: Did you receive?

PERSON B: hm – **no**.

PERSON A: **Never** saw any notification

In this case an increase in negations may not reflect antagonistic or poor quality communication, but it may reflect a more frustrating period of dialogue.

These preliminary results provide evidence that language use changed over time as group dynamics changed dramatically. These results suggest that future studies may be able to use certain language markers to identifying group level properties such as how well group members are working together, the quality of communication, group satisfaction. This study was limited because language was only examined in one group, however it suggests that tracking a group over time by using language from a public chat may reflect real group processes that are occurring. A longitudinal study that measured language use and surveyed participants about group coherence and performance would help establish the relationship between language and group dynamics. This is important research because it could provide a method for non-obtrusively evaluating work groups.

ROLE OF INDIVIDUAL GROUP MEMBERS AND LANGUAGE

Language use can also help identify the relationship between specific individuals and other group members. Individual differences, such as age, sex, and personality are reflected in the language people use (Pennebaker, Mehl, & Niederhoffer, 2003).

Language also changes depending on the relationship between individuals, for example individuals of higher relative status use different language (Sexton & Helmreich, 2000; Kacewicz et al., 2009). In this group language varied for individuals who had higher rated status, were rated as being more familiar, perceived more pressure from group members, and who experienced more interpersonal conflict.

Group members modified the language style that they used in order to be more similar to their conversation partner, in conversations between two individuals. Accommodating to one's conversation partner suggests that language style is dynamic medium and may reflect individual relationships.

These findings for the relationship between individual's social position in the group and language use support past literature. These findings also suggest an expansion in understanding how language reflects interpersonal relationships in small groups. Group members rated by others as having higher social status had lower average LSM in dyadic conversations. Accommodation theory would suggest lower status individuals are less likely to match in language to higher status individuals (Giles & Coupland, 1991). Instead, they would be more likely to engage in complementary language production. For example, out of respect lower status individuals may use less familiar words while higher status individuals may use more familiar words. In this dataset average rated social status is a combination of organizational position of leadership and familiarity. Person C, Person F and Person P held management positions and were rated as having high social status. On the other hand, Person A and Person E also held management positions and were rated as having low social status. Person L, a student intern, was rated as having high social status, despite having low organizational status.

In addition to a negative average LSM for higher status individuals, use of first person plural pronouns was positively related to rated social status. This finding is

consistent with past literature, which has found that use of first person plural is positively related to social status (Sexton & Helmreich, 2000; Kacewicz et al., 2009).

Individuals who rated that they felt more pressure from other group members used more assent words in the public chat. General agreeableness or pressure by others to offer feedback on statements may increase perceptions of pressure from other group members. Many of the group members who rated that they felt pressure from the group held positions of lower organization status. Person I, Person R, Person Q, and Person D all had high ratings and high use of assents. Person I was a student intern, Person D had been a student intern, Person Q was brought in from a different group, and while Person R was an employee she was not in a management position and telecommuted from out-of-state.

Both perceptions of experiencing interpersonal conflict in the group and rated familiarity by other group members were correlated with use of question marks. Individuals rated as more familiar used fewer question marks and individuals who experienced more interpersonal conflict used more question marks. In another study individuals of lower status used more question marks in flight simulations (Sexton & Helmreich, 2000). More peripheral individuals may ask more questions because they are less familiar with the content of discussion between central individuals. Person Q, Person L, Person H, and Person O rated that they experienced high interpersonal conflict and used more question marks. Person Q, Person H, Person G, and Person O were rated as less familiar and used more question marks. There is a clear overlap in the individuals who used a high rate of question marks and experienced more interpersonal conflict and were rated as less familiar.

Some language elements changed depending on how individuals were perceived within the group and how the individuals perceived their experience in the group. If some language features are reliable markers of the relative position of individual within a

group, then they can have predictive power. How individuals use language may indicate areas of improvement in group dynamics. For example, individuals who were rated as being less familiar by other group members used more question marks. These individuals may not have been as well informed as more central individuals. This finding may point to the importance of providing group knowledge in a way that is accessible to all group members. Future research could examine the relationship between language use of individuals in specific positions in the group and individual and group outcomes.

LIMITATIONS

This study was a preliminary examination of how language methods could help identify functional uses of communication in a group, changes in group dynamics and individual differences based on role within the group. There are few limitation of this dataset, and each language technique has some methodological constraints. Group computer –mediated communication have less equal participation than other forms of communication, even in a work group. Communication in the public chat was dominated by a few members who sent more messages. Some group members predominantly used other mediums of communication like private dyadic chat rooms.

This was an exploratory analysis, so a large number of analyses were conducted increasing the type I error rate. Further studies are needed to support and confirm these preliminary results. The usefulness of examining the language used in a small work group suggest that future studies with more definite outcome variables and a large sample size might find interesting results. In addition, since this group was undergoing a major change, when funding was threatened and then withdrawn, the results of these analyses may not be generalizable to work groups in which the future is certain and group members are not removed.

CONCLUSIONS

This paper shows how informal group communication captured from a public chat can be used to understand trends in group communication over time, the type of communication that occurs in a group, and how subtle shifts in group members' language can highlight roles of individuals in the group. These results contribute to study of real world work groups and problem solving. These methods could be applied to developing automatic research and management tools.

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Vita

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